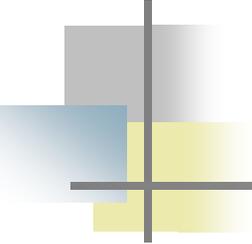


# Lecture 10

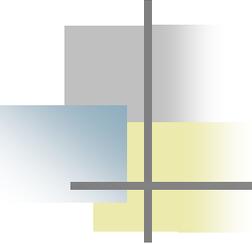
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# Interest and equivalence

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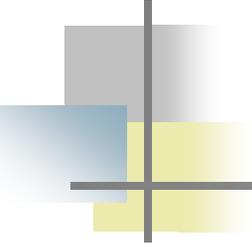
- Know how to obtain one value
  - $P$ ,  $F$ , or  $A$from another value
  - Given the interest rate and the number of time periods
- Know how to use:
  - $(P/A, i, n)$ ,  $(P/F, i, n)$ ,  $(F/P, i, n)$ ,  $(A/F, i, n)$ , etc.



# Unknown interest rates

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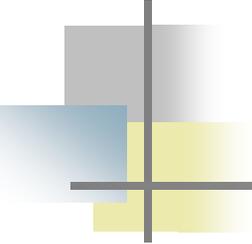
- Know how to get the interest rate in closed form:
  - When given  $P$ ,  $F$ , and  $n$
- Know how to get the interest rate using interpolation:
  - In more complex problems



# Compounding

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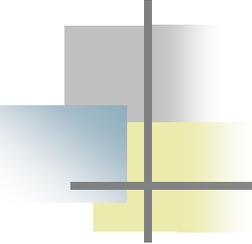
- Know how to use the formula:
  - $F = P (1+r/m)^{\# \text{ of periods}}$
- What is  $r$ ?
- What is  $m$ ?
  - $m$  and  $\#$  of periods must be measured in the same units



# Compounding (continued)

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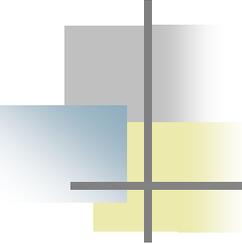
- Know how to convert a nominal annual rate to the corresponding effective rate when compounded:
  - Monthly, quarterly, semiannually, etc.and vice versa
- Know when to use:
  - $F = P (1+i)^n$and when to use:
  - $F = P (1+r/m)^{\# \text{ of periods}}$



# Present worth analysis

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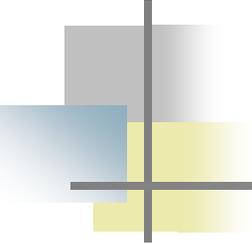
- Know how to select the best alternative based on present worth:
  - Know how to use  $(P/A, I, n)$
  - Know how to use  $(P/F, I, n)$
  - Remember to bring everything back to the present
  - Be aware of “gaps” between annual streams
- Know how to handle perpetual lifetimes
- What are the most important things to know and pitfalls to avoid in present worth?



# Annual equivalent cash flow

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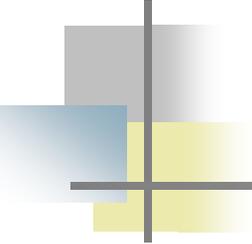
- Know how to use:
  - $(A/P, i, n)$ ,  $(A/F, i, n)$ ,  $(P/A, i, n)$ ,  $(F/A, i, n)$
  - Be aware of “gaps” between annual streams
- Know how to handle problems with different lifetimes:
  - Perpetual lifetimes
  - Why you don't need to convert to a common lifetime



# Internal rate of return

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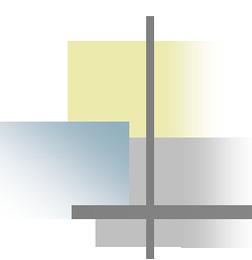
- Know what the concept means:
  - Internal rate of return is the value of  $i$  for which the present worth equals zero
- Know how to compare the internal rate of return to  $i^*$ :
  - When is an alternative desirable?
  - Remember that  $i^*$  is equal to the *minimum acceptable rate of return*
- Know how to obtain the internal rate of return from a set of costs and benefits



# Internal rate of return (cont.)

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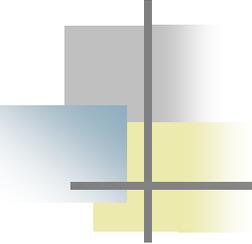
- What are the most important things to know and pitfalls to avoid in internal rate of return?



# Lecture 10

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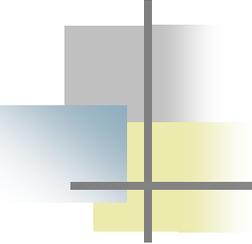
## Payback Period



# Definitions

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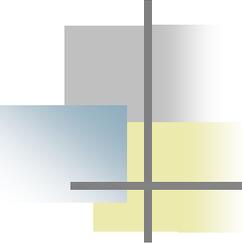
- Payback period:
  - Estimated time to recover initial investment
- Crude (or “no-return”) payback period:
  - Recover initial investment with no return
- Payback period with interest:
  - Recover initial investment plus return
    - (Time at which discounted future cash flow equals initial investment)



# Payback period

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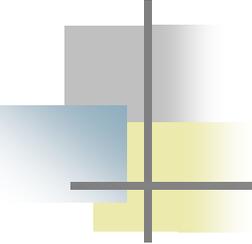
- Payback period is *not* an appropriate way to compare investments:
  - *All cash flows after the payback period are neglected!*
  - Not mathematically equivalent to present worth, annual equivalent, rate of return, and benefit/cost ratio
  - May neglect required return on investment



# Payback period

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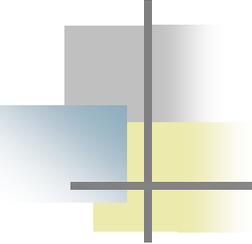
- This is a bad method!
  - Not equivalent to discounted cash flow methods
  - Ignores important information
- Nevertheless, it's commonly found:
  - No need for discounted cash flow calculations, minimum acceptable rate of return
  - Easy to understand
  - Favors events nearer in time (less uncertain)
- So we need to know about it



# Crude (simple) payback

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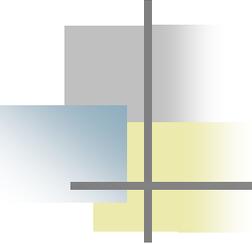
- Look for *the first time at which the sum of cash flows up to then is nonnegative:*
  - This is the “payback period”
- Example:
  - Cash flows of -1000, 500, 500
  - Payback period is 2
    - All dollars recovered by end of period 2



# More on crude payback

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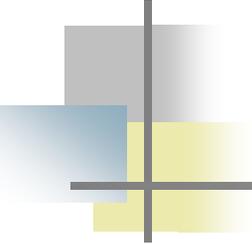
- Now consider another investment:
  - Cash flows of -1000, 0, 0, 10,000
- Discounted cash flow methods prefer this cash flow to the previous one at any MARR up to 300%:
  - Yet payback period is 3,
  - So crude payback test would prefer previous cash flow to this one!



# Discounted payback

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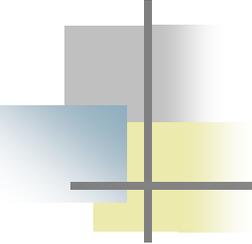
- Also known as “payback with time value of money”
- Now we change payback rule to look for:
  - *The first time at which the discounted present worth of cash flows up to then is nonnegative*
  - Use minimum acceptable rate of return for discounting
- This is used in place of crude payback period



# More on discounted payback

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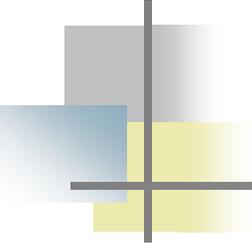
- This ignores any cash flows beyond the payback period
- Example:
  - Cash flow 1: -1500, 2000
  - Cash flow 2: -1500, 1000, 10,000
    - Crude payback test prefers cash flow 1
    - Discounted payback test prefers cash flow 1 at any rate of return between  $-33\%$  and  $+33\%$



# Payback period

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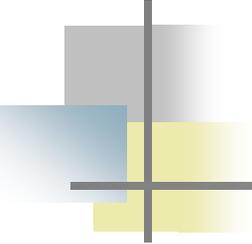
- Biases of payback period:
  - Tends to favor short-term projects
  - Can minimize beneficial investments



# My advice

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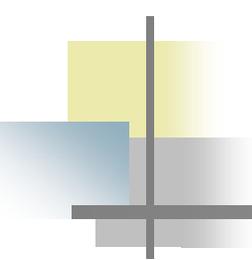
- Don't use payback in any form:
  - Crude or discounted
- Know what it is and how to use it:
  - In case your organization requires it
- Be prepared to argue for use of correct discounted cash flow methods:
  - If you have an opportunity to do so



# Payback period

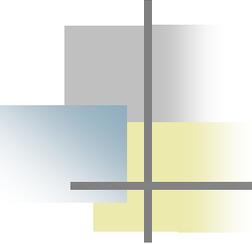
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- May be acceptable as a secondary criterion:
  - Especially if funds are very limited!
    - (E.g., in small businesses)
- Shorter payback period frees up funds sooner for other investments



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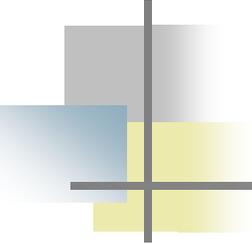
# **Breakeven Analysis**



## **Breakeven analysis**

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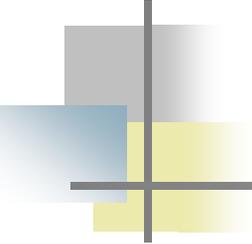
- **If all of the parameters for a problem are known except one:**
  - **Then the unknown parameter can be calculated or approximated**
- **Set present worth, future worth, or annual worth equal to zero:**
  - **And solve for (or approximate) the unknown parameter**



## Example

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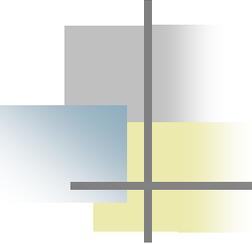
- **Your company is preparing a quote to machine 500,000 castings per year for 5 years**
- **The company will need to:**
  - **Purchase machining centers**
  - **Purchase or lease space**
  - **Hire labor**
- **What price should the company charge to earn 15% rate of return?**



## Example (continued)

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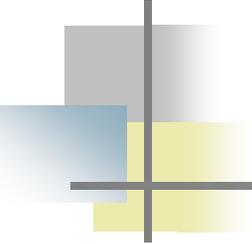
- **You could also specify fixed price per casting:**
  - **And determine how many castings your company would need to sell**
  - **To earn 15% rate of return**



## Solving for a breakeven value

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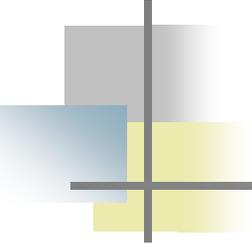
- **Ways of solving for an unknown parameter:**
  - **1. Direct solution (manually) – simple problems (e.g., just P and F)**
  - **2. Trial and error (manually) – slightly more complex problems**
  - **3. Spreadsheet model – can use Excel financial functions (PV, FV, RATE, IRR, NPV, PMT, NPER)**



## Problems with costs and revenues

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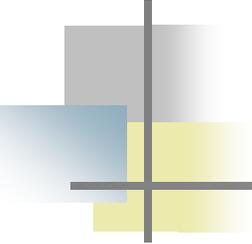
- **Breakeven analysis is commonly used to study relationships among costs, revenue, and volume:**
  - **Define cost and revenue functions**
  - **Linear (or non-linear) functions of volume, price, etc.**
- **Objective: Find the value (volume, price, etc.) that maximizes profits**



## **Fixed costs**

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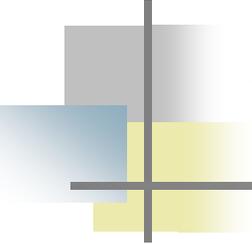
- **Do not vary with production or activity levels, price, etc.**
- **Examples:**
  - **Buildings**
  - **Insurance**
  - **Fixed overhead**
  - **Equipment**
  - **Etc.**



## Fixed costs

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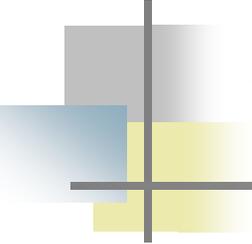
- **Constant for all values of the variable in question**
- **Even if no level of activity:**
  - **Fixed costs still continue!**
- **Must shut down the activity before fixed costs can be eliminated**
- **To compensate for fixed costs:**
  - ***You need a minimum volume or price!***



# Variable costs

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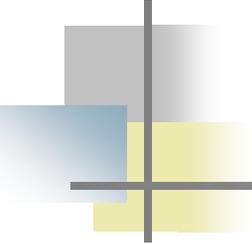
- **Vary with the level of activity**
- **Examples:**
  - **Direct labor (wages)**
  - **Materials**
  - **Indirect costs (e.g., fringe benefits)**
  - **Marketing**
  - **Advertising**
  - **Warranty**
  - **Etc.**



## Variable costs

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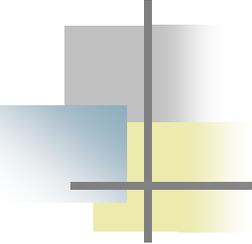
- **More activity (volume):**
  - **Greater variable costs**
- **Less activity (volume):**
  - **Lower variable costs**
- **Variable costs can also be affected by higher sales volume:**
  - **If non-linear function of volume**
  - **(E.g., economies of scale)**



# Total costs

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- **Total cost:**
  - **Fixed cost plus variable cost**
- **Profit:**
  - **Revenue minus total cost**

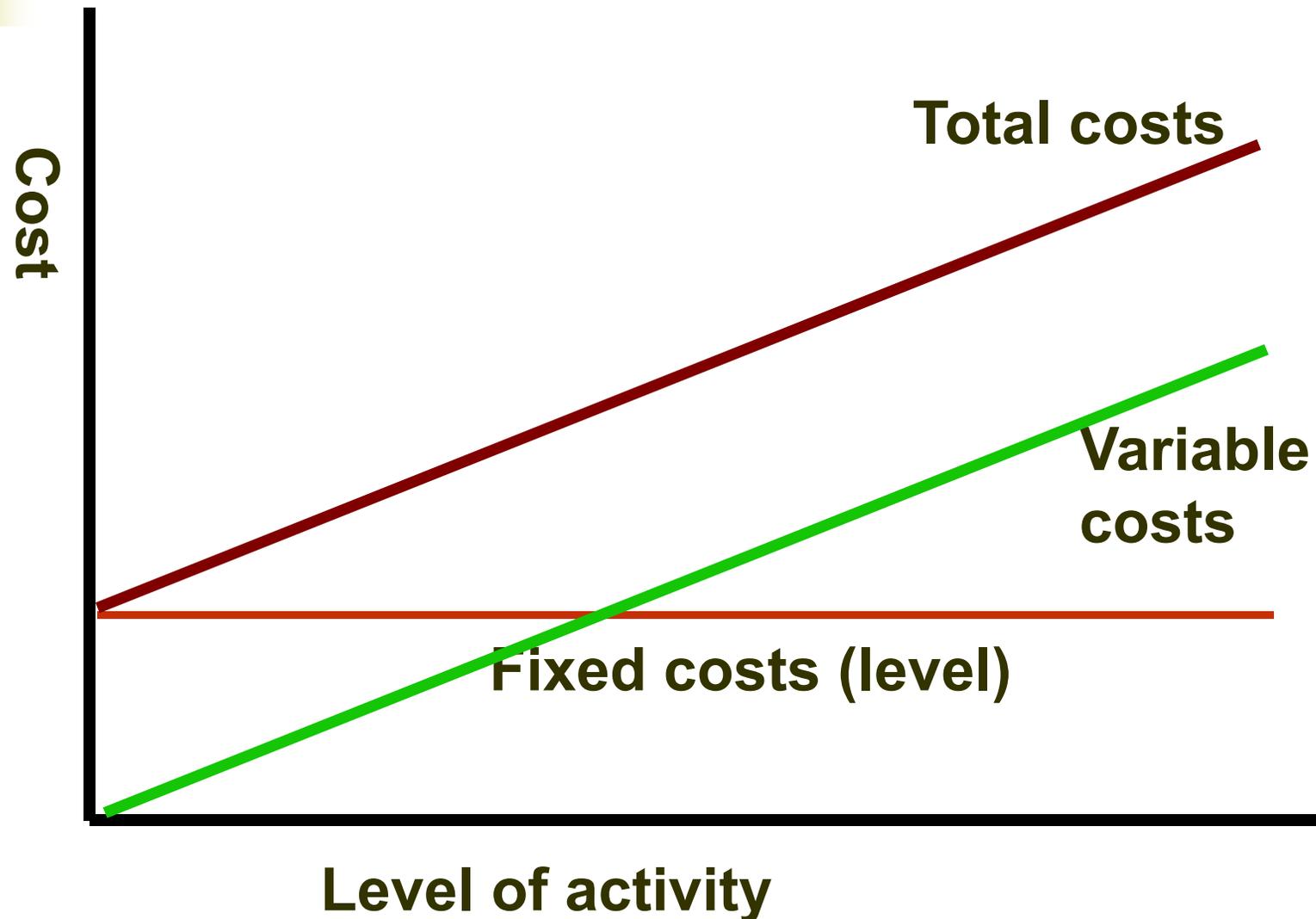


## Cost and revenue relationships

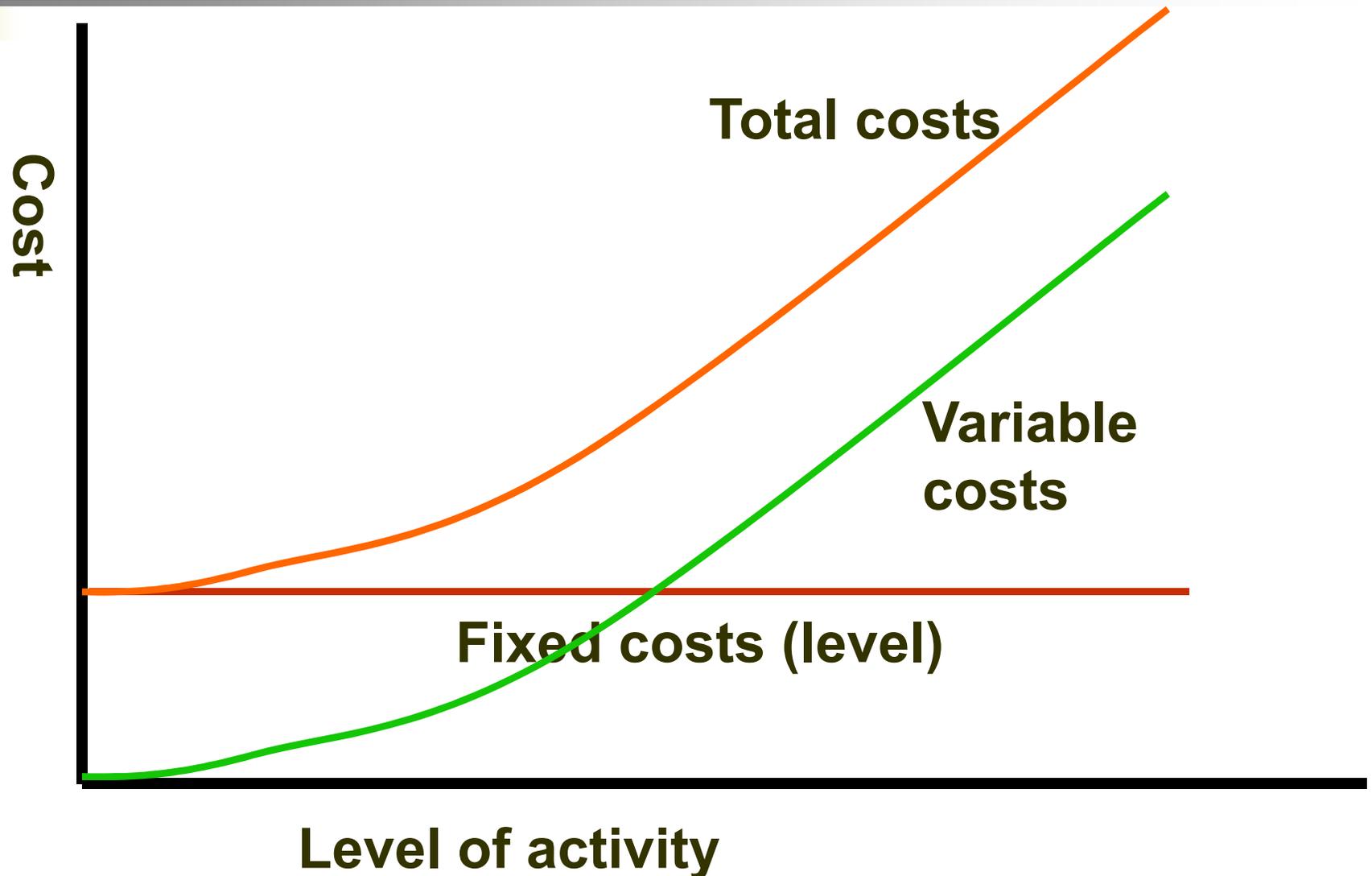
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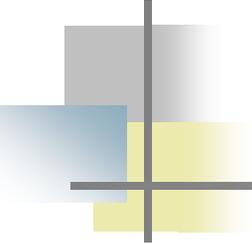
- **The relationship of cost and revenue to volume may be:**
  - **Linear, or**
  - **Non-linear (e.g., economies of scale)**
- **Both are just approximations**

# Linear cost relationship



# Non-linear cost relationship

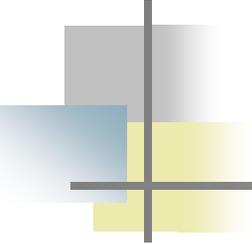




# Breakeven

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- **The breakeven point is the point where the revenue and total cost relationships intersect**
- **For non-linear functions:**
  - **It is possible to have more than one breakeven point!**

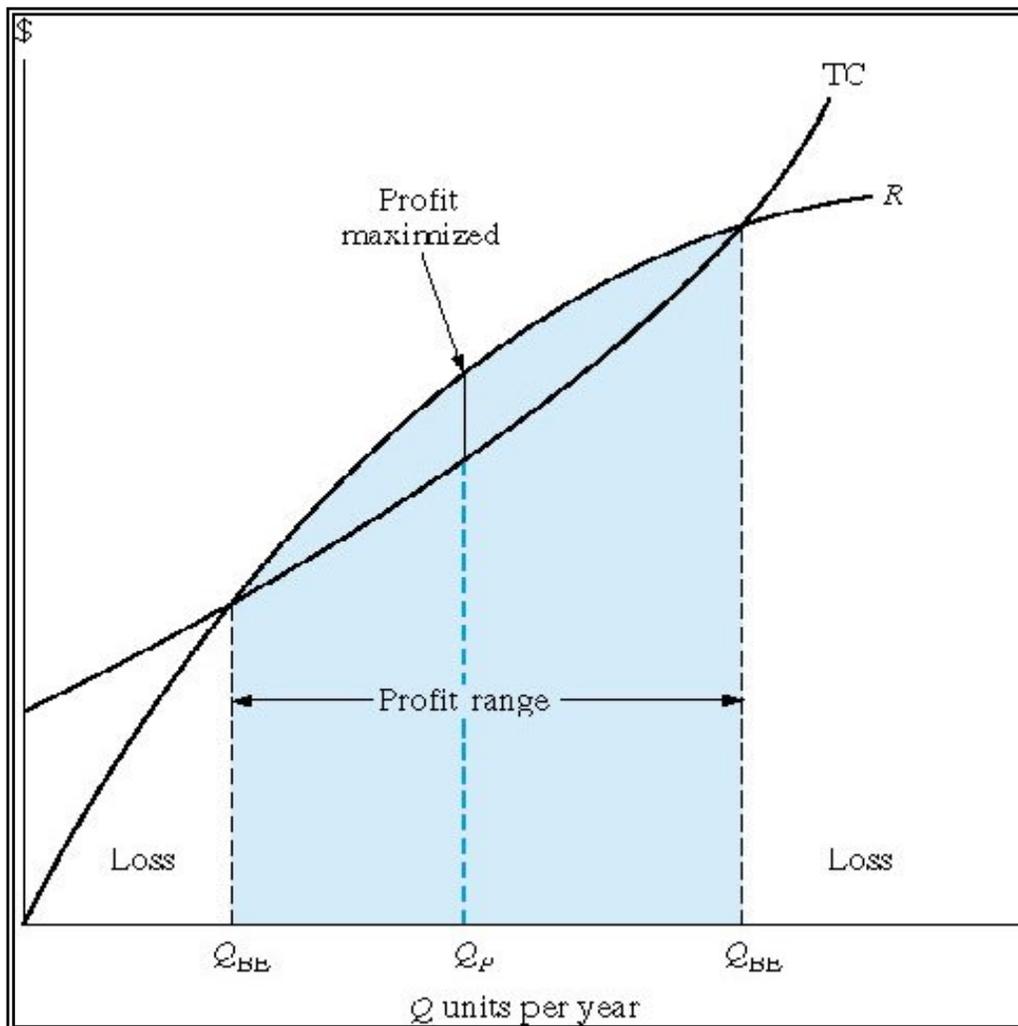


# Break-even

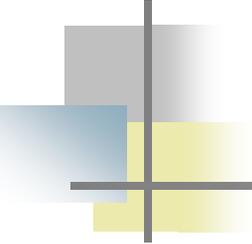
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- **Assumed revenue and cost relationships tend to be static:**
  - **May not reflect the reality of a dynamic firm**
  - **(E.g., reductions in variable cost, to improve efficiency)**
- **However, the break-even point can still be useful for planning purposes**

# Non-linear functions



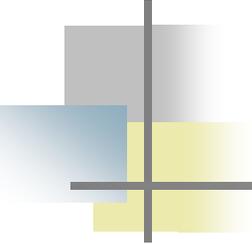
**Multiple breakeven points  
for a non-linear model!**



# Non-linear functions

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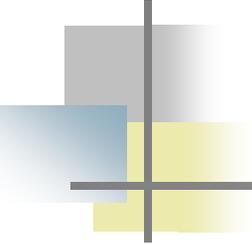
- **For non-linear functions:**
  - **There may be multiple breakeven points**
  - **Simply being above a breakeven point may not guarantee a positive profit**
  - **We want to find the level of volume or price that yields the maximum profit!**



## Summary

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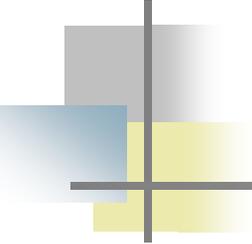
- **The breakeven point for a problem can be expressed as:**
  - **Units per time period**
  - **Hours per month**
  - **Price per unit**
  - **Etc.**
- **At breakeven, you are indifferent about whether to do the project**



# Summary

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- **Revenue and cost can be:**
  - **Linear, or**
  - **Non-linear**
- **Breakeven analysis is a form of *sensitivity analysis***
- **Complex models can be evaluated using Excel**



## Concept Quiz

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- **Can payback period be made consistent with present worth if implemented correctly?**
- **Name two important factors that are ignored by non-discounted payback period**
- **Why is payback period commonly used in practice?**
- **What can go wrong if decisions are made based on payback period?**